

TOP SECRET//~~NSA/CSS/60~~

What is Claimed is:

1. A liquid crystal display device comprising a liquid crystal panel in which a lower substrate having thin film transistors for switching for pixel selection on its inside surface and an upper substrate having color filters for plural colors on its inside surface are disposed in opposition to each other with a layer of a liquid crystal compound being interposed therebetween, and the lower substrate and the upper substrate are stuck to each other by a sealing material which is arranged to surround a display area of the upper substrate and has, in a portion, a cut which serves as a liquid crystal injecting port, the liquid crystal injecting port being sealed with an end-sealing material after a liquid crystal compound has been injected through the liquid crystal injecting port,

the amount of constituent components of the end-sealing material which exist as impurities in the liquid crystal compound is 1.0/10,000 or less of the total peak area value of the liquid crystal compound that is measured by gas chromatography/mass spectrometry.

2. A liquid crystal display device according to Claim 1, wherein the end-sealing material includes a methacrylic-group containing oligomer, one or more kinds of reactive dilution monomers, a photocrosslinked reaction initiator and a phenolic antioxidant.

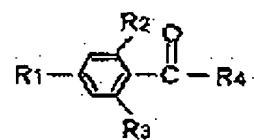
3. A liquid crystal display device according to Claim 2, wherein the one or more kinds of reactive dilution monomers are any one or ones of those noted in Table 1 shown below, the photocrosslinked reaction initiator is any one of those expressed by Chemical Formulae 1 and 2(i) to 2(vi), and the phenolic antioxidant is any one of those expressed by Chemical Formulae 3(i) to 3(iii)

noted below:

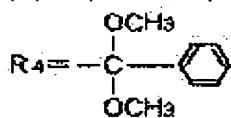
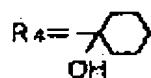
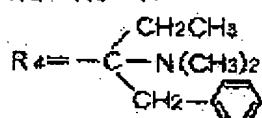
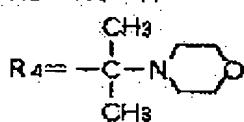
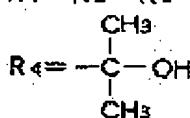
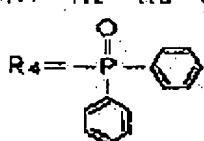
Table 1

Mono(meth)acrylic compounds such as methyl methacrylate, ethyl (meth)acrylate, *a*-butyl (meth)acrylate, 1-butyl (meth)acrylate, *t*-butyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, lauryl (meth)acrylate, stearyl (meth)acrylate, cyclohexyl (meth)acrylate, benzyl (meth)acrylate, phenyl (meth)acrylate, phenoxyethyl (meth)acrylate, phenoxypropyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, glycidyl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, phenylglycidyl (meth)acrylate, dimethylaminoethyl (meth)acrylate, phenyl cellosolve (meth)acrylate, *n*-vinyl-2-pyrrolidone (meth)acrylate, dicyclobentinyl(meth)acrylate, biphenyl (meth)acrylate, glycidyl methacrylic (meth)acrylate and 2-hydroxyethyl (meth)acryloylphosphate; monovinyl compounds such as styrene, vinyltoluene, chlorostyren, divinylbenzene, 1-vinylnaphthalene and 2-vinylnaphthalene; and multifunctional methacrylic compounds such as ethylene glycol di(meth)acrylate, diethylene glycol di(meth)acrylate, triethylene glycol di(meth)acrylate, tetraethylene glycol di(meth)acrylate, nonaethylene glycol (meth)acrylate, 1,3-butylene glycol di(meth)acrylate, 1,4-Butanediol di(meth)acrylate, trimethylolpropane tri(meth)acrylate, neopentyl glycol diacrylate, 1,6-hexamethylene di(meth)acrylate, hydroxy pivalic acid ester neopentyl glycol di(meth)acrylate, pentaerythritol tri(meth)acrylate, pentaerythritol tetra(meth)acrylate, dipentaerythritol hexa(meth)acrylate, and tris(meth)acryxyethyl isocyanurate.

Chemical Formula 1



Chemical Formulae 2(i) to 2(vi)

(i) $\text{R}_1 = \text{R}_2 = \text{R}_3 = \text{H}$ (ii) $\text{R}_1 = \text{R}_2 = \text{R}_3 = \text{H}$ (iii) $\text{R}_1 = \text{O}_2\text{N}-$ $\text{R}_2 = \text{R}_3 = \text{H}$ (iv) $\text{R}_1 = \text{H}_3\text{C}-\text{S}-$ $\text{R}_2 = \text{R}_3 = \text{H}$ (v) $\text{R}_1 = \text{R}_2 = \text{R}_3 = \text{H}$ (vi) $\text{R}_1 = \text{R}_2 = \text{R}_3 = \text{CH}_3$ 

Chemical Formulae 3(i) to 3(iii)

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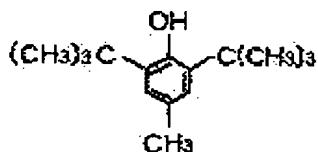
(i) Hydroquinone



(ii) Hydroquinone monomethyl ether



(iii) 2,6-Di-t-butyl-p-cresol



4. A method of manufacturing a liquid crystal display device including a liquid crystal panel in which a lower substrate having thin film transistors for switching for pixel selection on its inside surface and an upper substrate having color filters for plural colors on its inside surface are disposed in opposition to each other with a layer of a liquid crystal compound being interposed therebetween, comprising the steps of:

sticking the upper substrate and the lower substrate to each other by a sealing material which is arranged to surround a display area of the upper substrate and has, in a portion, a cut which serves as a liquid crystal injecting port;

applying an end-sealing material to the liquid crystal injecting port after the liquid crystal compound has been injected through the liquid crystal injecting port, the end-sealing material containing a reactive dilution monomer noted in Table 2, a photocrosslinked reaction initiator expressed by any of Chemical Formulae 4 and 5(i) to 5(vi) and a phenolic antioxidant expressed by

any of Chemical Formulae 6(i) to 6(iii); and

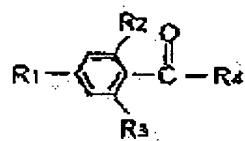
curing the end-sealing material by irradiation with ultraviolet rays in an accumulated light quantity of 4,000 mJ/cm² or more and heating and aging the cured end-sealing material:

Table 2

Mono(meth)acrylic compounds such as methyl methacrylate, ethyl (meth)acrylate, α -butyl (meth)acrylate, 1-butyl (meth)acrylate, t-butyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, lauryl (meth)acrylate, stearyl (meth)acrylate, cyclohexyl (meth)acrylate, benzyl (meth)acrylate, phenyl (meth)acrylate, phenoxyethyl (meth)acrylate, phenoxypropyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, glycidyl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, phenylglycidyl (meth)acrylate, dimethylaminoethyl (meth)acrylate, phenyl cellosolve (meth)acrylate, n-vinyl-2-pyrrolidone (meth)acrylate, dicyclobentinyl(meth)acrylate, biphenyl (meth)acrylate, glycidyl methacrylic (meth)acrylate and 2-hydroxyethyl (meth)acryloylphosphate; monovinyl compounds such as styrene, vinyltoluene, chlorostyren, divinylbenzene, 1-vinylnaphthalene and 2-vinylnaphthalene; and multifunctional methacrylic compounds such as ethylene glycol di(meth)acrylate, diethylene glycol di(meth)acrylate, triethylene glycol di(meth)acrylate, tetraethylene glycol di(meth)acrylate, nonaethylene glycol (meth)acrylate, 1,3-butylene glycol di(meth)acrylate, 1,4-Butanediol di(meth)acrylate, trimethylolpropane tri(meth)acrylate, neopentyl glycol diacrylate, 1,6-hexamethylene di(meth)acrylate, hydroxy pivalic acid ester neopentyl glycol di(meth)acrylate, pentaerythritol tri(meth)acrylate,

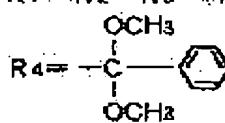
pentaerythritol tetra(meth)acrylate, dipentaerythritol hexa(meth)acrylate, and tris(meth)acryxyethyl isocyanurate.

Chemical Formula 4

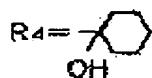


Chemical Formulae 5(i) to 5(vi)

(i) $R_1 = R_2 = R_3 = H$

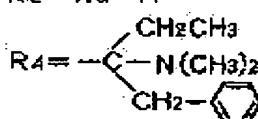


(ii) $R_1 = R_2 = R_3 = H$



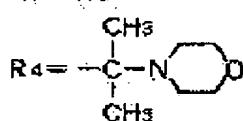
(iii) $R_1 = O-\text{C}_2\text{H}_4-\text{N}-$

$R_2 = R_3 = H$

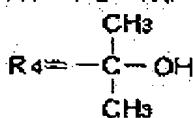


(iv) $R_1 = \text{H}_3\text{C}-\text{S}-$

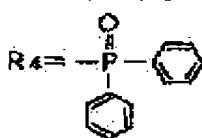
$R_2 = R_3 = H$



(v) $R_1 = R_2 = R_3 = H$



(vi) $R_1 = R_2 = R_3 = \text{CH}_3$



Chemical Formulae 6(i) to 5(iii)

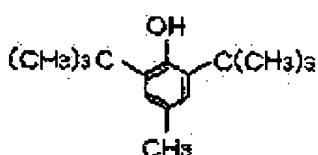
(i) Hydroquinone



(ii) Hydroquinone monomethyl ether



(iii) 2,6-Di-t-butyl-p-cresol



5. A method of manufacturing a liquid crystal display device according to Claim 4, wherein the amount of constituent components of the end-sealing material which exist as impurities in the liquid crystal compound after the heating-and-aging step is 1.0/10,000 or less of the total peak area value of the liquid crystal compound that is measured by gas chromatography/mass spectrometry.

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